TM-975
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Fermilab

# A DIGITAL MEASUREMENT SYSTEM FOR MONITORING HAZARDOUS ATMOSPHERES IN ENCLOSED AREAS

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## 1. Introduction

For many years, flammable gases have been used in various ways in enclosed spaces. Recently cryogenic fluids that boil off to become nonflammable gas displacing atmospheric oxygen have come into common use. Both situations present problems from a health and safety standpoint.

Leakage from apparatus containing flammable gas poses the problem of gas reaching its flammable limit in air. Sufficient concentrations can be ignited by electrical discharge or careless use of cigarettes in the area where gas could collect.

Normal boiloff of cryogenic fluids displace small amounts of air with nonflammable gas. Abnormal venting of excessive pressure, or significant spills can displace large volumes of air, reducing the percentage of breathable oxygen in an enclosed area. Persons working in the area, unless warned by others or monitoring devices, would be unaware of the lack of oxygen. Excessive carbon dioxide in the blood is the primary stimulant to increase breathing. Since carbon dioxide is expelled from the lungs in an atmosphere that contains a lack of oxygen no buildup occurs in the blood. Hypoxia occurs too quickly to the victim for him to take action on his own. If he realizes what is happening at all it is too late for him to save himself.

In order to protect personnel and equipment from possible explosion, fire, or non life supporting atmospheres, measuring devices sensitive to undesirable conditions are normally installed in the hazardous area. Many different units are available commercially. These units use some type of transducer that converts a gas concentration in air to either a variation in resistance or voltage proportional to the percentage by volume at atmospheric pressure. The electronics package associated with these sensors is commonly a device consisting of several integrated circuit type amplifiers that increase the incoming signal level and perform comparison with adjustable trip level voltage settings. Buffering is provided for these amplifiers to drive relays for connection to external alarms.

While these units perform their functions well as designed, several intrinsic flaws exist in the units currently in use. In all of the systems investigated, internal components could fail giving no indication of failure. Backup circuitry was not provided to continue protection in the event of a failure. Trip level settings were easily readjustable by unauthorized personnel. This is an undesirable situation from a safety standpoint.

## 2. Specification

It was decided that the available units were unsatisfactory because of the possibility of unseen loss of protection. Design criteria were outlined for the construction of a measurement system that would meet tighter safety standards at a reasonable cost. The new system should be redundant to prevent loss of protection by failure of one component. It should be fail safe with a loss of supply power. It should display current levels of measured gas concentration. It should be easy to adjust and

check trip settings deliberately. It should be difficult for unauthorized personnel to change trip settings without detection.

With little or no modification all of the requirements can be met with a unit already in use as a magnet current monitor. The current monitor unit takes the form of a NIM module that interlocks bending magnet currents into a radiation safety system. (See also TM-944,2817.000, 3/5/80).

3. Implementation

The module for use as a hazardous atmosphere monitor, known as a dual set point monitor module, contains two independent systems for redundant protection from failure. Each system uses an isolated operational amplifier at the sensor input to isolate internal circuitry from external grounds and associated noise pickup. The output of this op-amp is converted to a digital number by a dual slope integrating analog to digital converter. By converting the signal to a digital number at this point, offsets and gain changes due to time and temperature are eliminated from that point on. Because the data from the A/D converter is multiplexed, a set of latches is used to retain the two most significant digits of the data for comparison to a reference. These two digits would correspond to tens and units digits of percent concentration. All four digits available are displayed on the front of the module for channel A only. The two most significant digits are compared to two digital reference settings by two sets of comparators. Two settings, one high and one low, can be programmed in with rotary dip switches mounted inside on the circuit board. The comparator outputs are buffered by drivers that actuate relays for interfacing to external circuitry. In total, two high level and two low level settings are provided. They are independently adjustable in one percent increments from zero to 99.00 percent. Light emitting diodes are provided on the front panel to indicate trips and to show sampling rate of the A/D con-

verters. The module requires + 15, - 15 and + 5 volts for operation.

A small number of external components are required to interface either an oxygen or flammable gas detector to the monitor module. For the oxygen sensor, only a resistive voltage divider is necessary to provide the proper input level. A little more is required for the flammable gas detector. A constant current regulated power supply is needed to excite the sensing heads. Typically an ampere of current is used with sensors made by Control Instruments Corp. this supply should be interlocked in case of failure. In addition, two resistors that complete the other half of a Wheatstone bridge with the sensors, and a zeroing pot are needed to complete the circuit.

## 4. Conclusion

Experimental trials with both oxygen and flammable gas detectors have demonstrated that the dual set point monitor module is a superior alternative to commercially available units. Not only is the monitor module inherently safer, but because it is an in house unit built at Fermilab, it is considerably less expensive. Interchangeability of parts and modules is a possibility by using similar units for multiple applications. A full schematic diagram is available as Meson Lab Print No. 2816-ED-95150.